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Energy Procedia 30 (2012) 350 – 352

Energy Procedia

SHC 2012

Thermally enhanced paraffin for solar applications

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Abstract

Compact thermal energy storage for solar applications requires new phase change materials with higher thermal energy storage capacities. In this study, nano magnetite (Fe_2O_3) particles were prepared with the sol-gel method to be used for enhancing thermal properties of paraffin. 10% nano particle was added to paraffin (melting range: 56-58 °C and latent heat: 119 J/kg) to prepare a nano composite. SEM analysis shows that nano magnetites are homogeneously distributed in paraffin structure with particle size in the range of 15-25 µm. Latent heat of the paraffin nano composite measured by DSC was 144 J/g. This result indicated that thermal storage capacity of paraffin can be increased by about 20% by addition of 10% nano magnetite. Further analysis on determining thermal conductivity and thermal stability is ongoing.

Keywords: Compact thermal energy storage; phase change material; nano composite; paraffin

1. Introduction

Developing new materials for compact thermal energy storage is a significant issue for especially solar applications in buildings. Paraffin is an abundant and thermally stable phase change material (PCM) used in latent heat storage. Unlike many inorganic PCMs, it does not have any supercooling or incongruent melting problems. On the other hand thermal energy storage capacity of paraffins is lower than inorganics. Another drawback is the low thermal conductivity.

Nano materials with the increased surface area relative to volume are advanced materials and used in various applications for different purposes including enhancing thermal properties [1]. In this study, nano-

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doi:10.1016/j.egypro.2012.11.041

composite of paraffin is developed for increasing thermal energy storage capacity and thermal conductivity. Nano- magnetite used here is prepared with the sol-gel method..

2. Materials and methods

Paraffin (Merck) with phase change temperature 56-58°C and latent heat of 119 J/g is used as the PCM. Nano magnetite (Fe_3O_4) was synthesized from Fe^{+2} and Fe^{+3} salt hydrates by sol-gel method according to the following chemical reaction [1].

$$Fe^{2+} + 2Fe^{3+} + 8OH^- \rightarrow Fe_3O_4 + 4H_2O \quad (1)$$

Nano magnetite particles were stabilized by 1% oleic acid to avoid oxidation and to obtain discrete particles.

Magnetic susceptibility analysis and Fourier Transform Infrared – FTIR spectroscopy were carried out to characterize the synthesized nano magnetite. Further analysis to determine the morphology and size distribution of nano magnetite particles and composites was done by Scanning Eletron Microscope– SEM (Jeol JSM-5500LV).

The phase change temparature and latent heat of the samples were determined by Differential Scanning Calorimeter– DSC (Perkin Elmer Diamond). The DSC used is a power compensating one with an intracooler. The heating and cooling rate used was 5°C/min.

Paraffin nano composite samples were prepared by mixing 10% stabilized nano magnetite in melted paraffin using vortex device at 1000 rpm.

3. Results

3.1. Characterization of nano-composite PCM

FTIR spectrum and magnetic susceptibility results confirmed the synthesized products by sol-gel method were magnetite. SEM analysis of stabilized nano particles given in Figure 1(a) shows the uniform particle size and spherical shape. Figure 1(b) shows that nano magnetites are homogeneously distributed in paraffin structure with particle size in the range of 15-25 µm.

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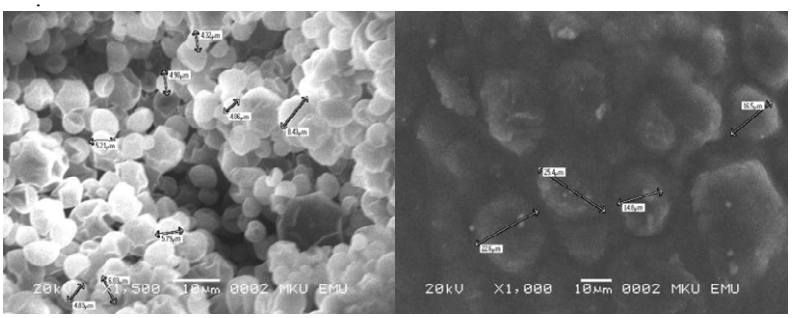

Fig. 1. SEM results a) nano magnetic samples b) paraffin nano composites

3.2. Thermal storage capacity

DSC thermogram of paraffin nano composite is shown in Figure 2. The latent heat obtained was 144 J/g and the phase change interval was 56 - 61°C. This value of latent heat is 20% more than paraffin without nano materials.

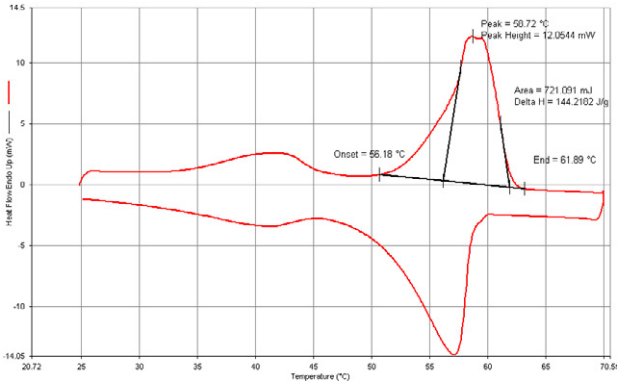

Fig. 2. DSC results of paraffin with 10% nano magnetite

4. Conclusions

DSC results show that latent heat storage capacity of paraffin has been increased by 20%, when 10% nano magnetite was used in the composite. The thermal conductivity of magnetite is about 50 times higher than paraffin. Therefore a significant increase in thermal conductivity of paraffin nano composite can also be expected. With these properties, the developed thermally enhanced paraffin nano composite is a candidate for compact thermal energy storage solar applications. Further analysis to determine thermal stability and thermal conductivity of the composites is in progress. The effects of increasing nano content and using different nano particles are also investigated.

Acknowledgements

The authors would like to acknowledge the support provided by TUBITAK under the Project No 110M032.

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